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ABSTRACT

This study investigated the relationships among student and group characteristics, group interaction, and achievement in cooperative small groups. Seventy-seven students in two junior high school mathematics classrooms learned a two-week unit on exponents and scientific notation in mixed-ability or uniform-ability groups. Interaction in the groups was tape recorded. Three categories of interaction related to achievement: receiving no explanation in response to a question or error (receiving no response or receiving only the correct answer) was negatively related to achievement; giving explanations and receiving explanations were positively related to achievement. Interaction in the group was related to group composition, sex, ability, and personality. Medium-ability students in uniform-ability groups received more explanations (and showed higher achievement) than medium-ability students in mixed ability groups. Boys received more explanations (and showed higher achievement) than girls. High-ability students gave more explanations than low-ability students. Extroverted students received more answers to questions than introverted students. Interaction in the group was not related to ethnic background: white, black, and Asian-American students showed similar interaction patterns (and achievement). The advantages of taperecording over other observational procedures are discussed in terms of capturing sequences of student interaction. (Author/MP)

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Abstract

This study investigated the relationships among student and group characteristics, group interaction, and achievement in cooperative small groups. Seventy-seven students in two junior high school mathematics classrooms learned a two-week unit on exponents and scientific notation in mixed-ability or uniform-ability groups. Interaction in the groups was tape-recorded. Three categories of interaction related to achievement: receiving no explanation in response to a question or error (receiving no response or receiving only the correct answer) was negatively related to achievement; giving explanations and receiving explanations were positively related to achievement. Interaction in the group was related to group composition, sex, ability, and personality. Medium-ability students in uniform-ability groups received more explanations (and showed higher achievement) than medium-ability students in mixed-ability groups. Boys received more explanations (and showed higher achievement) than girls. High-ability students gave more explanations than low-ability students. Extroverted students received more answers to questions than introverted students. Interaction in the group was not related to ethnic background: white, black, and Asian-American students showed similar interaction patterns (and achievement). The advantages of tape-recording over other observational procedures are discussed in terms of capturing sequences of student interaction.

Group Interaction and Learning in the Mathematics Laboratory and the Regular Classroom

In the last few years, educational researchers have started to become aware of the need to examine interaction among students to understand the impact of cooperative small groups on learning. This research is still in an embryonic stage, however; few studies have directly investigated the interactional processes that affect learning in small groups. Two issues need to be addressed: the relationship between group interaction and achievement in small groups, and the impact of characteristics of the group and of its members on interaction and achievement. The present study addresses both issues. The purposes of this study are first, to replicate the findings from the few studies that have been done, and second, to clarify and extend these findings by analyzing verbatim records of student interaction obtained from audio tape-recordings of group interaction.

The interaction variables examined in previous studies that have investigated the relationship between group interaction and achievement include giving help and receiving help.[1] Peterson and Janicki (1979) and Peterson, Janicki, and Swing (in press) found that giving help was positively related to achievement. Webb (1980a, 1980b, 1980c) further showed that students who gave explanations learned more than students who did not give explanations, even when ability was held constant.

The findings relating receiving help and achievement are not as consistent nor as straightforward as those relating giving help and achievement. Rather, they suggest that receiving help is an amalgam of several variables with different effects on achievement. Only one of the studies mentioned above reported a significant relationship between receiving help and achievement (Webb, 1980a). Intensive re-examinations of the data in that study revealed, however, that whether the help received was beneficial for achievement depended on two factors: (1) the student behavior that elicited the help and (2) the nature of the help received (Webb, 1980c). First, receiving help was beneficial only when the target student gave evidence of needing help. Such evidence included making errors and asking questions. Second, the help received

was beneficial only when it included an explanation of how to solve the problem. Merely being told the correct answer without an accompanying explanation of how to obtain it was not sufficient for a student who made errors or asked questions to learn how to solve the problem. The results of another recent study corroborated these findings, showing that receiving help was effective only when given in response to student need (Webb, 1981). Further, in that study receiving no help in response to a question was highly detrimental to achievement. The present study, then, distinguished between solicited and unsolicited help, investigated whether calls for help were answered, and analyzed the nature of the help received.

Of the group characteristics used to predict interaction and achievement in small groups, group ability composition has been investigated most frequently. The group composition most often studied is the mixed-ability group with one high-ability, one low-ability, and two medium-ability students. Webb (1980a, 1980d) found that, compared to working in uniform-ability groups in which all students had the same ability level, working in mixed-ability groups was beneficial for high-ability and low-ability students. Medium-ability students, however, learned more in uniform-ability groups than in mixed-ability groups. Similar results appeared in the study by Peterson, Janicki, and Swing (in press) which compared achievement in mixed-ability small groups and large groups. High-ability and low-ability students did better in small groups than in large groups, but medium-ability students did slightly better in large groups than in small groups. The findings of interactions between group setting and ability were partially explained by verbal interaction in the group. In Webb's study, highs and lows showed more helping behavior in mixed groups than in uniform groups, whereas mediums were more active in uniform groups than in mixed groups. In the Peterson et al. study, highs and lows also did more explaining than mediums in mixed groups. The present study concentrated on the effect of group composition on the interaction and achievement of medium-ability students. It was expected that medium-ability students would give and receive more help and would show greater achievement in uniform groups than in mixed groups.

The few individual characteristics that have been used to predict interaction in small groups working on academic tasks include ability,

personality (extroversion-introversion), ethnic background, and sex. The most consistent findings involve ability. Several studies have reported that high-ability students give more explanations than low-ability students (Peterson & Janicki, 1979; Peterson, Janicki, & Swing, in press; Webb, 1980a, 1980d, 1981); two of these reported additional curvilinear relationships showing depressed participation among medium-ability students in mixed-ability groups (Peterson, Janicki, & Swing, in press; Webb 1980a, 1980d). Surprisingly, few of these studies found a significant relationship between ability and receiving explanations. Those that did reported that low-ability students received more explanations than high-ability students (Webb, 1980a, 1980d). A somewhat different finding appeared in one study: low-ability students were more likely than high-ability students to receive no responses to their questions (Webb, 1981). Based on these results, it was expected that ability would be positively associated with giving help. The results for receiving help were too inconsistent, however, to provide a basis for any expectation.

Only one study investigated the relationship between personality and interaction. Webb (1981) found that introverted students were less likely then extroverted students to receive responses to their questions.

Several studies have examined the relationships between ethnic background and interaction in the group. In multiracial groups, white students tend to be more active and influential than minority students (Cohen, 1972; Cohen & Roper, 1972), while minority students tend to be less assertive, talk less, and give fewer suggestions and less information than white students (Battle & Rotter, 1963; Delbecq & Kaplan, 1968; Katz, Roberts, & Robinson, 1965; Lefcourt & Ladwig, 1965). Cohen (1972, 1973) attributed these results to status differences between white and minority students. Only by manipulating white students' and minority students' expectations of each others' performance were Cohen and her colleagues able to alter the usual pattern of white dominance in group interaction (Cohen, 1973; Cohen & Roper, 1972; Cohen, Lockheed, & Lohman, 1976). Their field experiments focused on increasing white students' expectations of black students' future competence. Because no efforts were made in the present study to alter students' expectations for performance, it was expected that minority students would give fewer

explanations than white students and would be more likely not to receive responses to their questions.

Very few studies have examined interaction in mixed-sex groups (Maccoby & Jacklin, 1974), and their results generally show no differences in interaction patterns between males and females (see, for example, Sgan & Pickert, 1980). Lockheed (1976), however, found an equal distribution of activity for males and females only when group members had prior experience with the material; when students had no prior experience, males tended to dominate group activity. The scarcity of research on sex differences in interaction patterns and the complexity of the results make it difficult to generate a hypothesis here. The analysis of sex differences in this study is, therefore, exploratory.

The present study investigated the relationship between student interaction and achievement, and between group and individual characteristics and interaction in mixed-ability and uniform-ability small groups in junior high school mathematics classes. Individual predictors of interaction and achievement included ability, personality, sex, and ethnic background. One of the major features distinguishing this study from the others described above is its systematic analysis of tape recordings of small group interaction in the classroom.

Method

Subjects

The sample consisted of 77 students in grades 7 and 8. The students came from two above-average general mathematics classes at a junior high school in the Los Angeles metropolitan area. Approximately 43% of the students were female and approximately 26% were minority (black, Asian-American). Because the mathematics classes at this school are tracked by ability rather than by grade, each class had students from both grades. Both classes were taught by the same teacher.

Instruments

Ability test. The ability test was a test of mathematics reasoning. The 40-item test was part of a test battery developed by mathematics teachers at the school for use in assigning students to classes. The test was administered to all students at the beginning of the school year. Internal consistency alpha for the mathematics reasoning test was .80. The scores in this sample ranged from 20 to 38 out of a maximum of 40 points ($M = 31.2$, $SD = 3.3$).

Personality measures. At the beginning of the study, students completed the extroversion-introversion scale of the Eysenck Personality Inventory (Eysenck & Eysenck, 1968) and the Intellectual Achievement Responsibility Scale (Crandall, Katkovsky, & Crandall, 1965). The latter scale assesses the degree to which students believe that they (not others) are responsible for their intellectual and academic performance. For this sample, internal consistency alpha was .56 for the extroversion-introversion scale and was .73 for the intellectual achievement responsibility scale.

Achievement test. The achievement test was a 20-item teacher-made test in which items were parallel in content and form to the problems students completed in class work. Internal consistency alpha for the achievement test was .88.

Group interaction variables. Interaction among students during group work was recorded on an audio recorder. Transcriptions of the tapes provided information about interaction among students, as well as the identity of speaker and recipient of each interchange. Tallies were

made of the number of occurrences of each of thirteen interaction variables. The interaction variables and examples of each appear in Table 1. To assess the generalizability of the interaction variables, a generalizability study (Cronbach, Gleser, Nanda, & Rajaratnam, 1972) was conducted in which two persons coded the same random sample of half of the transcripts of group interaction. The estimated generalizability coefficients for one coder appear in Table 1. The coefficients were judged to be high enough that one coder analyzing the transcripts was sufficient.

It should be noted that the number of tallies for speakers and recipients of utterances did not always match. For example, within a group the frequency of giving explanations was sometimes different from that of receiving explanations. A higher frequency of giving explanations than receiving them occurred when several students participated in giving an explanation to another student. A lower frequency of giving explanations than receiving them occurred when a student gave an explanation to several students. Similar discrepancies occurred between the number of responses given to procedural questions and the number of responses received.

Procedure

Assignment of students to groups. Group composition was determined on the basis of ability. Scores on the test of mathematics reasoning served as the ability measure. Three ability strata were defined--high, medium, and low--corresponding to the top 25%, the middle 50%, and the bottom 25% of the sample. Because the mean and range of the sample (M = 31.2, range = 20 to 38) were above those for the school (M = 26.4, range = 4 to 38), low-ability and medium-ability students were low or medium relative to the sample, but not relative to the school. Students within ability strata were randomly assigned to groups. Mixed-ability groups had one high-ability, one low-ability, and two medium-ability students. Uniform-ability groups had three or four medium-ability students. Half of the groups were mixed; half were uniform. All groups had boys and girls, and had white and minority students.

Because a major comparison in this study focuses on medium-ability students learning in mixed-ability versus uniform-ability groups, medium-ability students in the two grouping conditions were matched on all measured characteristics. Statistical tests showed that the efforts to

Table 1

Interaction Variables

Interaction Variable	Example	Generalizability coefficient[a]
Receives no explanation		
Makes error, is not corrected	Error: 10^3 times 10^{-1} is 10^{-2}.	.86
Makes error, receives correct answer without explanation	Error: 10^1 divided by 10^3 is 10^2. Response: No, it's 10 to the negative 2.	.74
Asks for explanation, receives no response	Question: How do you do #18?	.86
Asks for explanation, receives answer without explanation	Question: Wait, how do you do #20? Response: It's 10^{-7}.	.81
Asks procedural question, receives no response	Question: What question are you on?	.93
Receives explanation		
Makes error, receives explanation	Error: 10^3 divided by 10^1 is 10^3. Response: You minus [the exponents], remember. You don't divide, you subtract. Remember, when you divide, it's A [the numerator's exponent] minus B [the denominator's exponent]. So it's 10^2.	.96
Asks for and receives explanation	Question: How did you get 10 to the second for $\frac{10^5}{10^4}$ x 10? Response: You subtract [the exponents] and get [10 to the] one, and you multiply it by [ten to the] one, and get 10 to the second.	.82

Table 1 (cont.)

Interaction Variable	Example	Generalizability coefficient[a]
Gives explanation	Response: Okay, look. 63,000,000 times 8,500,000. This is 63 with 6 zeroes. So, in parentheses, 63 times 10 to the sixth and then times 85 times 10 to the fifth ... 5355 ...	.75
Receives response to procedural question	Question: Do we have to write the decimal [equivalent of the exponent] too? Response: Yeah.	.69
Gives short-answer feedback		
Answers procedural question	Question: Do you have to turn to the right now? Response: Yeah, 12 times.	.81
Corrects error	Error: 10^5 times 10^{-4} is .01. Response: No, it's 10.	.68
Gives correct answer to problem	Answer: $(3 \times 10^2)^2$ ... that'll be 90 ... 90,000.	.85
Performs calculations	Calculations: I'm doing the decimal first. See ... 2 times 10^3, that'll be thousand, that'll be 2,000 ... then ...	.88

[a]Estimated generalizability coefficient for one coder.

match students were successful; among medium-ability students, mixed and uniform groups had equal ratios of girls to boys ($\chi^2(1) = .06$, $p < .81$), equal ratios of white students to minority students ($\chi^2(1) = 1.65$, $p < .20$), and had nearly identical means on ability ($t(42) = 0.80$, $p < .43$), extroversion-introversion ($t(42) = 0.42$, $p < .68$), and intellectual achievement responsibility ($t(42) = 0.74$, $p < .46$).

Classroom activities. During the week before group work, students received their group assignments and "practiced" working in their groups to become familiar with the small group setting and with the recording procedures.

The study started at the beginning of the following week. Students learned a two-week unit on exponents and scientific notation. Students worked on exercises from their textbook (Dolciani, Wooton, Beckenbach, & Markert, 1967) as well as on exercises prepared by the teacher. A new set of exercises was assigned each day. Both classes learned the same material and followed the same schedule of activities. At the beginning of the first day, students received instructions for group work. Students were told to work together and not to divide the work, to help group members experiencing difficulty, and to ask for help if they needed it. They were instructed to ask the [redacted] for help only if no one in the group could solve the problem. To promote cooperation, students were given group grades (the average of group members' scores) in addition to their individual grades on the achievement test. The reward structure was, therefore, a combination of individual competition and intergroup competition-intragroup cooperation. Deutsch (1949, 1960) showed that intragroup cooperative rewards promotes cooperation, helpfulness, and coordination of efforts among group members.

During group work all students worked on the same exercises. The teacher monitored group work by answering questions, by providing hints when groups could not proceed, and by ensuring that students did not work with members of other groups or bother other groups.

Every group was tape recorded at least once for at least 15 minutes. The order of tape-recording the groups was random. For taping, a small microphone was clipped to

each group member's shirt. The microphones were connected to one channel of a hand-held stereo tape-recorder. The observer, under headphones, spoke numbers that identified the speaker of each utterance into a microphone that was connected to the other channel. Using extension cords, the observer could stand eight to ten feet away from the group, thereby reducing the chances of distracting group members. The transition from one group to another typically took less than a minute. Most groups did not even stop working when the microphones were clipped on and taken off.

During the week after small group work, students completed the achievement test. Students worked individually on the test without help from other students or from the teacher.

Results

Interaction and Achievement

Table 2 presents the means and standard deviations of the interaction variables and achievement and the correlations between interaction variables and achievement. The interaction variables in Table 2 are grouped in six categories. The first three categories, "receives no explanation", "receives explanation", and "gives explanation", correspond to observation categories examined in previous research. The remaining three categories, "receives response to a procedural question", "gives short-answer feedback", and "performs calculations", represent other kinds of interaction that occurred in group work. Each mean represents the frequency of occurrence per 45-minute class period.

As can be seen in Table 2, the three categories of interaction found by previous research to relate to achievement--receiving no explanation, receiving explanations, and giving explanations--were significantly related to achievement in this study.[2]

Receiving no explanation in response to an error or question had by far the greatest relationship with performance on the achievement test. Students who often received no response to their errors or questions, or who received only the correct answer without an explanation showed lower achievement than students who rarely experienced this problem. The correlations between achievement and variables within this interaction category reveal two additional effects. First, receiving no response at

Table 2

Means, Standard Deviations, and Correlation Coefficients of Achievement and Interaction

Measure	M	SD	r with Achievement
Achievement	12.5	3.4	
Receives no explanation[a]	12.2	16.1	-.57***
Makes error, is not corrected	2.4	5.8	-.31***
Makes error, receives correct answer without explanation	3.2	6.2	-.25**
Asks for explanation, receives no response	2.5	5.4	-.44***
Asks for explanation, receives answer without explanation	1.5	3.3	-.37***
Asks procedural question, receives no response	2.6	5.0	-.43***
Receives explanation[a]	6.5	8.7	.22**
Makes error, receives explanation	1.6	3.8	.17*
Asks for and receives explanation	4.9	6.9	.18*
Gives explanation	6.6	8.2	.26**
Receives response to procedural question	8.1	10.3	-.03
Gives short-answer feedback[a]	21.3	19.3	-.01
Answers procedural question	8.1	8.8	-.15
Corrects error	3.2	5.0	.14
Gives correct answer to problem	10.0	14.4	.04
Performs calculations	58.5	36.1	-.05

[a]Composite = sum of measures in category

*$p < .10$

**$p < .05$

***$p < .01$

all had a greater negative effect on achievement than did receiving only the correct answer. To determine the statistical significance of the difference between the effect of receiving no response and that of receiving an answer without an explanation, the following procedure was used. Composite variables for receiving no response and for receiving an answer without an explanation were formed by summing the scores on the relevant interaction measures. Each composite was then correlated with achievement. The difference between the correlations (-.54 between achievement and receiving no response, -.36 between achievement and receiving an answer without an explanation) was tested using Hotelling's test for the difference between correlations computed for the same sample (Hotelling, 1940). The difference was marginally significant ($t(74) = 1.65$, $p < .06$, one-tailed test).

The second effect apparent from Table 2 is that not receiving an explanation in response to a question had a greater negative impact on achievement than not receiving an explanation in response to an error. Using Hotelling's procedure, as before, the difference between the correlation between achievement and not receiving an explanation in response to a question (-.53) and the correlation between achievement and not receiving an explanation in response to an error (-.35) was marginally significant ($t(74) = 1.53$, $p < .08$, one-tailed test).

Receiving explanations in response to errors or questions had a positive relationship with achievement, although the relationship was considerably weaker than that between achievement not receiving explanations. The effects on achievement of receiving explanations in response to errors and receiving explanations in response to questions were much the same. Further, inspection of the means of receiving and not receiving explanations (see Table 2) reveals that 55% of the questions were answered with explanations, whereas only 22% of the errors prompted explanations from other group members. This latter finding suggests that students usually did not recognize or did not acknowledge that those who made errors needed explanations of how to solve the problems.

Giving explanations was positively related to achievement. Students who frequently gave explanations to other group members scored higher on the achievement test than students who rarely gave explanations.

The other three categories--receiving responses to questions, giving short-answer feedback, and performing calculations--were not significantly related to achievement. For the remaining analyses, only the results for the three categories of interaction that were related to achievement will be presented.

The Effects of Group Ability Composition on Interaction and Achievement

The purpose of forming the two ability group compositions used in this study, mixed-ability groups with one high-ability student, one low-ability student, and two medium-ability students, and uniform-ability groups with all medium-ability students, was to examine the effects of group composition on the achievement and interaction of medium-ability students. It was hypothesized that, compared to medium-ability students in mixed groups, medium-ability students in uniform groups would (1) score higher on the achievement test and (2) receive and give more explanations.

The means and standard deviations for achievement, ability, and interaction variables are presented by group composition in Table 3. The results confirmed the first hypothesis. Medium-ability students in uniform groups obtained higher achievement test scores, on the average, than medium-ability students in mixed groups. In fact, medium-ability students in mixed groups tended to score lower than low-ability students (for low-ability students, $\underline{M} = 12.1$, $\underline{SD} = 3.9$), although the difference was not statistically significant.

The second hypothesis, concerning medium-ability students' experiences in group interaction, was partially confirmed (see Table 3). Mediums in uniform groups received more explanations in response to their errors and questions than did mediums in mixed groups. The results for receiving no explanations were mixed. Significant differences appeared in two variables, but in opposite directions. The result in the expected direction is that mediums in uniform groups were less likely than mediums in mixed groups to receive only the answer in response to questions. The result in the unexpected direction is that mediums in uniform groups were more likely than mediums in mixed groups to receive no response to procedural questions. The results for giving explanations

Table 3

Ability, Interaction, and Achievement of Medium-Ability Students in Homogeneous and Heterogeneous Groups

	Homogeneous (n=29)		Heterogeneous (n=15)		
	M	SD	M	SD	t
Achievement	12.7	3.0	10.9	3.3	1.78*
Ability	31.4	1.4	31.1	1.4	0.80
Receives no explanation[a]	12.0	15.0	10.3	11.9	0.38
Makes error, is not corrected	2.4	6.4	1.9	3.0	0.27
Makes error, receives correct answer without explanation	3.8	5.7	2.7	8.2	0.51
Asks for explanation, receives no response	1.8	4.8	2.3	4.8	0.34
Asks for explanation, receives answer without explanation	0.6	1.8	2.4	3.7	2.18**
Asks procedural question, receives no response	3.4	5.1	0.8	2.4	1.80*
Receives explanation[a]	10.1	10.5	3.9	4.8	2.78**
Makes error, receives explanation	2.5	3.8	0.8	2.2	1.64
Asks for and receives explanation	7.6	8.8	3.1	3.8	1.87*
Gives explanation	8.0	10.3	3.7	6.2	1.45

[a]Composite = sum of measures in category.

*$p < .10$

**$p < .05$

***$p < .01$

were in the expected direction--mediums in uniform groups gave more explanations than mediums in mixed groups--but the difference was not statistically significant.

In summary, the results of the comparison between medium-ability students in mixed-ability and uniform-ability groups confirmed the expectation of the study. Medium-ability students showed higher achievement, received more explanations, and tended to give more explanations in uniform groups than in mixed groups.

Individual Characteristics Predicting Interaction and Achievement Ability.

Because medium-ability students had different experiences in uniform-ability and mixed-ability groups, pooling all students in an analysis of the relationship between ability and interaction and achievement might have masked different effects for uniform groups and mixed groups. Therefore, the relationships between ability and interaction and achievement were analyzed separately for students in mixed groups and for students in uniform groups.

The relationship between ability and achievement differed between the grouping conditions. In mixed-ability groups, the relationship between ability and achievement was positive (r = .25, $p < .05$). Further examination of the data, however, revealed a significant curvilinear relationship between ability and achievement. The curvilinear relationship was examined by computing a stepwise multiple regression equation to determine whether an $(\text{ability})^2$ term predicted achievement over and above ability. The $(\text{ability})^2$ term significantly increased the variance accounted for in achievement. The regression coefficients for ability and $(\text{ability})^2$ were -3.41 (F = 4.83, $p < .05$, R^2 = .06) and .06 (F = 5.51, $p < .02$, change in R^2 = .10), respectively. The graph of the curvilinear relationship appears in Figure 1. Although high-ability students did better than low-ability students, on the average, medium-ability students tended to obtain lower achievement test scores than both high-ability and low-ability students. In uniform-ability groups, in contrast, the relationship between ability and achievement was linear (r = .37. $p < .02$); the $(\text{ability})^2$ term did not add to the prediction of achievement (change in $R^2 < .001$). The graph of the regression equation

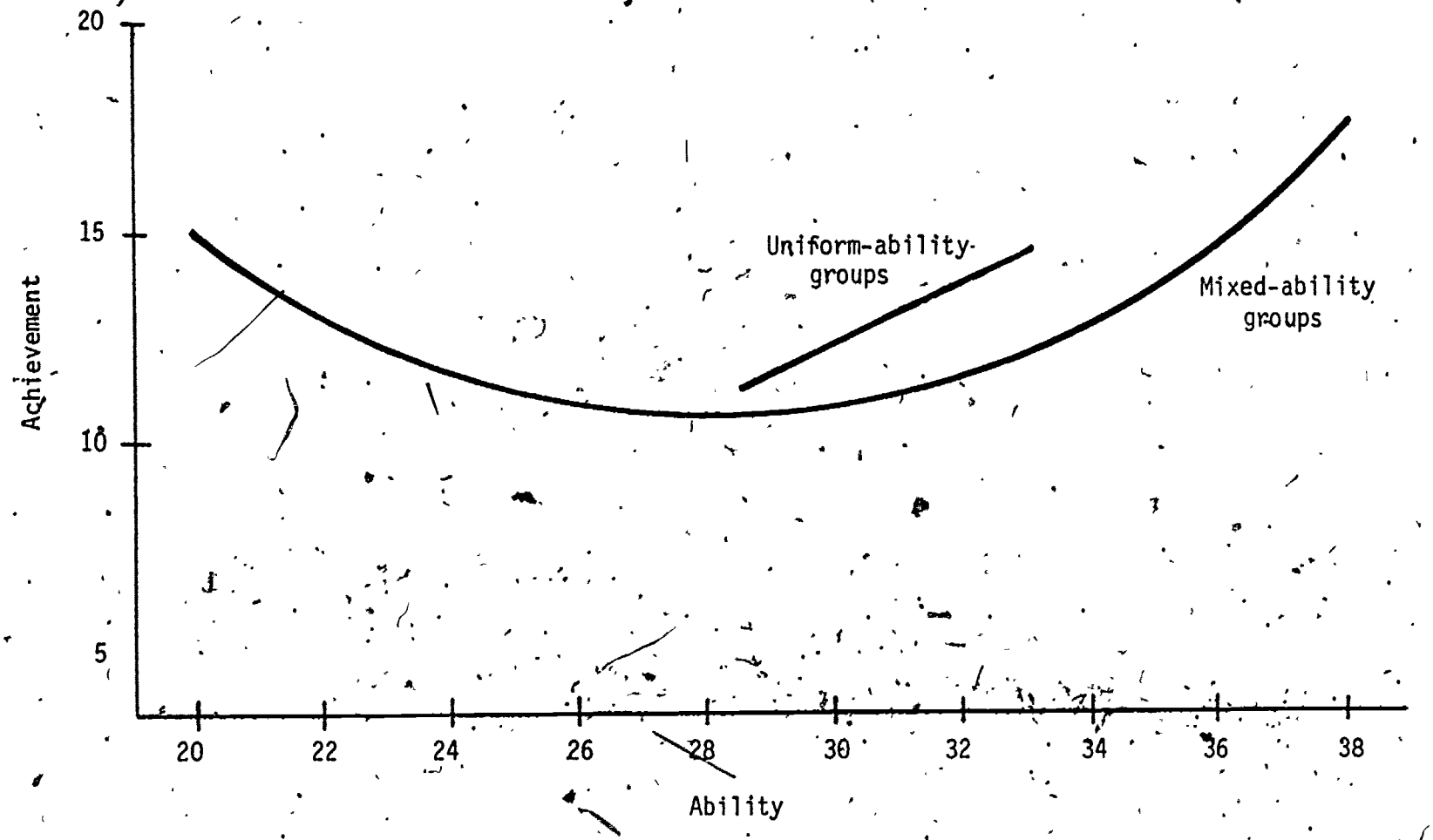

Figure 1. Regression of Achievement on Ability

for students in uniform groups appears in Figure 1. The disparity in achievement between medium-ability students in uniform and mixed groups shows the extent to which working in mixed groups depressed the performance of medium-ability students.

Unexpectedly, few of the interaction variables were related to ability, and the significant findings appeared only in mixed-ability groups. The significant relationships that emerged were, however, consistent with previous findings. Ability was negatively related to asking a procedural question and receiving no response ($r = -.24$, $p < .05$) and was positively related to giving explanations ($r = .24$, $p < .05$). Low-ability students were more likely than high-ability students to fail to receive responses to their procedural questions, and high-ability students gave more explanations than low-ability students. Ability was unrelated to receiving explanations. There were no curvilinear relationships between ability and interaction.

Sex. A potent individual predictor of achievement and group interaction was the sex of the student. Although males and females had similar ability ($M = 31.3$ and 30.9 for males and females, respectively), males scored higher on the achievement test than females ($M = 13.6$ and 11.1, respectively; $t(75) = 3.37$, $p < .001$). Closer inspection of the results by sex for different ability levels, however, showed that this effect was true only for medium-ability and low-ability students. Among high-ability students, girls and boys performed the same, on the average. The results for medium- and low-ability students were much the same; therefore, they were combined for the analysis discussed here. The results by sex, then, are presented for high-ability and for medium- and low-ability students (see Table 4).

As can be seen in Table 4, medium- and low-ability girls were less likely than boys to be corrected when they made errors and to receive responses when they asked for explanations or asked precedural questions. Furthermore, boys received more explanations when they asked for them than did girls. Among high-ability students, in contrast, boys and girls gave and received similar numbers of explanations.

Ethnic background. The results of achievement, ability and interaction in the group for students with different ethnic backgrounds are presented in Table 5. As can be seen in this table, the achievement of

Table 4

Ability, Interaction, and Achievement of Female and Male Students

Measure	High-ability					Medium- and low-ability				
	Females (n=8)		Males (n=9)			Females (n=25)		Males (n=35)		
	M	SD	M	SD	t	M	SD	M	SD	t
Achievement	13.2	3.4	14.7	3.2	0.88	10.4	3.2	13.3	3.0	3.61***
Ability	35.0	0.8	35.5	1.4	0.98	29.6	2.0	30.3	3.1	0.92
Receives no explanation[a]	9.2	15.0	12.7	18.8	0.42	16.4	17.1	9.6	14.8	1.63
Makes error, is not corrected	0.5	1.5	3.2	8.1	0.92	4.0	7.6	1.4	3.9	1.72*
Makes error, receives correct answer without explanation	2.9	4.5	3.5	7.0	0.21	1.7	3.8	4.2	7.6	1.48
Asks for explanation, receives no response	3.4	5.6	1.5	3.3	0.87	4.4	7.2	1.3	3.9	2.13**
Asks for explanations, receives answer without explanation	1.4	4.0	3.1	5.1	0.75	1.7	3.2	1.0	2.6	0.88
Asks question, receives no response	1.0	1.8	1.4	2.2	0.46	4.6	6.8	1.7	4.2	2.02**
Receives explanation[a]	5.3	3.0	3.7	8.1	0.53	4.8	7.6	8.7	10.2	1.61
Makes error, receives explanation	1.5	3.0	0.0	0.0	1.54	1.5	4.9	2.0	3.6	0.46
Asks for and receives explanation	3.8	3.6	3.7	8.1	0.03	3.3	4.5	6.7	8.2	1.85*
Gives explanation	5.9	7.6	9.9	6.5	1.16	7.1	9.6	5.6	7.8	0.63

[a]Composite = sum of measures in category.

*$p < .10$

**$p < .05$

***$p < .01$

Table 5

Ability, Interaction, and Achievement by Ethnic Background

Measure	Whites (n=57) M	Whites (n=57) SD	Blacks (n=10) M	Blacks (n=10) SD	Asian-Americans (n=10) M	Asian-Americans (n=10) SD	F
Achievement	12.8	3.3	10.5	4.2	13.1	2.8	2.10
Ability	32.0	2.7	27.3	3.9	30.2	2.9	11.59***
Receives no explanation[a]	11.9	16.2	19.8	20.1	5.9	6.9	1.94
Makes error, is not corrected	2.1	5.6	6.0	8.1	0.4	1.4	2.73*
Makes error, receives correct answer without explanation	3.1	6.1	3.4	7.3	3.5	6.1	0.03
Asks for explanation, receives no response	2.7	5.6	3.8	6.4	0.6	1.8	0.93
Asks for explanation, receives answer without explanation	1.7	3.5	1.5	3.4	0.4	1.4	0.61
Asks question, receives no response	2.4	4.6	5.1	8.1	0.9	1.9	1.92
Receives explanation[a]	7.8	9.5	3.3	3.2	2.6	5.4	2.33
Makes error, receives explanation	2.1	4.3	0.4	1.2	0.0	0.0	1.81
Asks for and receives explanation	5.7	7.5	2.9	3.3	2.6	5.4	1.36
Gives explanation	6.9	8.7	3.6	5.7	7.8	7.1	0.82

[a]Composite = sum of measures in category.

*$p < .10$

**$p < .05$

***$p < .01$

white, black, and Asian-American students were not significantly different. Concerning interaction patterns, black students showed a greater tendency than white or Asian-American students to be ignored when they made errors or asked questions. Only one interaction variable showed a statistically significant difference across students with different ethnic backgrounds, however: makes an error and is not corrected. Blacks were more likely than whites or Asian-Americans to fail to be corrected when they made errors. This result is not taken very seriously, however, because it was only marginally significant and because ethnic groups did not differ significantly on any other interaction variable.

Personality. Of the two personality measures used in this study, extroversion-introversion and intellectual achievement responsibility, only extroversion-introversion showed any significant relationships with interaction and achievement. Introverted students scored higher on the achievement test than extroverted students ($r = -.20$, $p < .04$). Extroversion-introversion related to only two interaction variables: receives only the answer in response to a request for an explanation ($r = .18$, $p < .06$) and receives an explanation in response to a request for one ($r = .22$, $p < .03$). Extroverted students were more likely than introverted students to obtain at least an answer if not an explanation when they asked for an explanation.

Explanatory Models

To determine the best predictors of achievement and interaction, stepwise multiple regression equations were comptuted. The order of entry of the predictors into the equation was based on the extent to which variables had been examined in previous research. Variables previously examined were entered first and new variables examined in the present study were entered last. In this way, the unique contribution of the new variables could be tested. The results of these analyses are presented in Table 6.

As can be seen in the regression equation predicting achievement, sex predicted achievement over and above ability, but extroversion-introversion and group composition did not. When the other variables were held constant, high-ability students achieved more than low-ability students and boys achieved more than girls. The most dramatic result in Table 6 is the potency of receiving no explanation as a predictor of achievement. This interaction category accounted for nearly half of the

Table 6

Multiple Regression Equations Predicting Achievement and Interaction for the Entire Sample (n = 77)

	Achievement			Receives Explanation			Gives Explanation		
	b	R^2	F	b	R^2	F	b	R^2	F
Individual characteristics									
Ability	.22	.06	5.23**	.16	.00	.29	.63	.04	4.45**
$(\text{Ability})^2$	.03	.06	3.04*	.05	.00	.74	-.10	.01	2.39
Sex	1.54	.10	6.45**	2.50	.03	1.65	-1.20	.00	.39
Extroversion-introversion	-.14	.02	2.27	.60	.05	4.02**	.02	.00	.01
Group ability composition	-.23	.01	.11	-5.95	.09	7.75***	-3.46	.03	2.69
Interaction variables									
Gives explanation	.04	.03	1.44						
Receives explanation[a]	.05	.02	2.04						
Receives no explanation[a]	-.10	.21	29.26***						
Full model	—	.52	9.03***	—	.17	2.95	—	.09	1.36

Note: Regression coefficients are unstandardized partial regression coefficients.

[a]Sum of measures in category.

*$p < .10$

**$p < .05$

***

explained variance over and above the contributions of the other variables in the model. Furthermore, neither receiving explanations nor giving explanations significantly predicted achievement when the effects of not receiving explanations were controlled.

In the prediction of interaction, extroversion-introversion and group composition were significant predictors of receiving explanations. Extroverted students received more explanations than introverted students, and students in uniform-ability groups received more explanations than students in mixed-ability groups. Only ability predicted giving explanations when the effects of other individual and group characteristics were held constant. High-ability students gave more explanations than low-ability students. The equation predicting receiving no explanations is not presented because none of the variables was significant (highest $F = .97$) and because all of the predictors together accounted for less than 3% of the variance in receiving no explanations.

Discussion

Summary of the Findings

Important findings emerged with respect to relationships between interaction and achievement and between group and individual characteristics and interaction. Concerning interaction and achievement, the more frequently a student asked a question or made an error and failed to receive an explanation, the worse was that students' performance on the achievement test. The more often a student received an explanation in response to a question or error or gave an explanation, the better was that student's performance.

The best predictors of interaction in the group were ability composition of the group and sex of the student; student ability, personality, and ethnic background predicted interaction less well. Medium-ability students in uniform-ability groups achieved more and received more explanations than medium-ability students in mixed-ability groups. Boys showed greater achievement and received more explanations than girls. High-ability students gave more explanations and received more responses to procedural questions than low-ability students. Extroverted students were more likely to receive answers to questions than were introverted students. White, black, and Asian-American students showed similar achievement and experiences in group interaction.

Interaction and Achievement

The relationships between interaction variables and achievement that emerged in the present study not only replicate the results of previous studies, but they also help to explain the strong relations for some interaction variables and the weak relations for others in previous research. The most potent predictor of achievement in this study was not receiving an explanation in response to an error or question; this experience was detrimental to achievement. This predictor included receiving no response at all and receiving the correct answer without an explanation. The detrimental effects of not receiving any response to a question and not having an error corrected are hardly debatable. Since errors indicated misunderstanding about how to solve the problems, and questions usually signified lack of understanding, receiving no response

at all would leave intact the student's misunderstanding or lack of understanding. More importantly, receiving only the correct answer was not sufficient for students to be able to understand or correct their mistakes, nor to discover how to solve the problem.

In contrast to not receiving explanations, receiving explanations did help students who made errors or asked questions learn the material, although the fairly low correlation between receiving help and achievement suggests that the explanations were not always effective. Whether training in peer tutoring may help promote more effective explaining remains to be investigated.

In addition to the major finding that receiving no explanation was detrimental to achievement, the procedures used in this study allowd subtle distinctions to be made among interaction variables in this category. First, the detrimental effect of receiving only the correct answer was not as great as that of receiving no response. This finding suggests that some students may have been able to infer the alogrithm for solving the problem from the correct answer. Second, the negative impact of receiving no explanation in response to an error was not as great as that of receiving no explanation in response to a question. Students who made errors seemed to have some notion of how to solve the problem, even if their notions were incorrect. Students who asked for explanations, on the other hand, often seemed unable to begin to solve the problem. Students with partial understanding of the material (those who made errors) would be more likely to infer the correct alogrithm than would students with no understanding (those who asked for explanations).

The importance of receiving help when needed and of elaborated responses to questions and errors agrees with the results of two recent studies of cooperative small groups (Webb, 1980d, 1981), and finds support in a recent large-scale study of first-grade reading groups. Although the First-Grade Reading Group Study (Anderson, Evertson, & Brophy, 1979) investigated teacher-led small groups with little overt interaction among students, its findings parallel those found here. Receiving terminal feedback to an error--in which the teacher stated the correct answer, asked another student to supply the answer, or allowed another student to call out the answer--was negatively related to

achievement. Receiving process feedback to an error--in which the teacher explained how to obtain the correct answer--was positively related to achievement. Anderson et al. did not compare the effects on achievement of terminal and process feedback to students' questions.

The importance of receiving help when needed and of elaborated responses also helps to explain the weak and inconsistent findings in previous studies relating receiving help and achievement (for example, Peterson & Janicki, 1979; Peterson, Janicki, & Swing, in press; Webb, 1980b, 1980d, 1981). First, most of the studies did not distinguish between needed and unneeded help. Receiving help would not be expected to relate highly to achievement for those students who already understood the material. Second, the studies did not distinguish between terminal responses and elaborated feedback. It is likely that the help received in these studies sometimes consisted of explanations and sometimes consisted of only the correct answer. The positive and negative effects of the experiences probably cancelled out, producing the near-zero relationships found in most of the studies.

The positive relationship between achievement and giving explanations in the present study confirms the findings in previous studies (Peterson & Janicki, 1979; Peterson, Janicki, & Swing, in press; Webb, 1980b, 1980c). There are two possible interpretations of this relationship. First, students who gave many explanations may have achieved more than students who gave few explanations because they had higher ability. Second, giving explanations may have helped the explainer learn. The positive correlation between ability and giving explanations provides some support for the first interpretation, but the weakness of the correlation suggests that the second interpretation also has merit.

Research on vocalization during problem solving and research on cognitive benefits of teaching suggest two mechanisms that might explain why giving explanations helps the explainer learn. The first mechanism is cognitive rehearsal that occurs when students verbalize material. As a result of cognitive rehearsal, students who verbalize how to solve the problem may remember the algorithm better than students who do not. Support for this hypothesis come from discrimination-learning studies in which vocalized stimuli were recalled more often than nonvocalized stimuli (e.g., Carmean & Weir, 1967; Di Vesta & Rickards, 1971; Weir &

Helgoe, 1968) and from problem-solving studies in which vocalizing during practice of a problem-solving task produced greater performance than not vocalizing (e.g., Gagne & Smith, 1968; see also Davis, 1968). The second mechanism is cognitive restructuring, in which students giving explanations reorganize the material for clearer presentation. Support for this mechanism comes from a recent study by Bargh and Schul (1980), in which students studying verbal material to teach it to another student learned more than students instructed only to learn it. Students in the teaching condition showed superior achievement of both the basic message and peripheral details of the material. Further research is needed to clarify these mechanisms. For example, evidence of cognitive restructuring might come from analysis of explanations given in group work or from stimulated recall of cognitive processes during explaining.

Group and Individual Characteristics Predicting Interaction and Achievement

The results for group ability composition replicated previous findings that medium-ability students learn more and participate more in uniform-ability groups than in mixed-ability groups (see Webb, 1980a, 1980d). The term "middle-ability" may reflect this finding more accurately than "medium-ability," however, since the effect depended on the relative standing within the group rather than on absolute ability level. Data from a previous study suggest that the most able students may perceive a responsibility toward the least able member of the group but not to those with medium ability, and thus tend to ignore them (Webb, 1980b, 1980d). In future studies, post-experimental interviews with students may provide additional explanations for the depressed participation and achievement among medium-ability students in mixed-ability groups.

The findings with respect to ability--the positive relationship between ability and achievement, and between ability and giving explanations, and the finding of no relationship between ability and receiving explanations--are also consistent with previous findings (Peterson & Janicki, 1979; Peterson, Janicki, & Swing, in press; Webb, 1980a, 1980b, 1980d). The persistent lack of significant findings for receiving help is counterintuitive, however, and cannot be explained further with the data in this study.

In contrast to the expected differences between group compositions and between ability levels, the difference between the achievement of male and female students was unexpected. Although past research has often reported male superiority in mathematics achievement (Glennon & Callahan, 1968), recent findings suggest that sex differences do not appear until high school (Callahan & Glennon, 1975; Hilton & Berglund, 1974), and even these findings have been challenged since differences tend to disappear when the amount of exposure to mathematics is controlled (Fennema, 1974; Fennema & Sherman, 1977). The interaction patterns of girls and boys may help to explain why boys did better than girls in the present study. Boys received more explanations than girls and were less likely to be ignored when they asked questions. The reasons for these interaction results are unclear, however. One possible explanation may be related to the finding that girls in this age group have less confidence in their ability to learn mathematics than males do (Fennema & Sherman, 1978; Sherman, 1980). Girls may have been less aggressive than boys in seeking help. A question that remains to be investigated is whether girls would receive more explanations in all-female groups than in mixed-sex groups.

Also unexpected were the findings for ethnic background. The results of similar achievement and similar interaction patterns among minority and white students in the present study contradict Cohen and colleagues' findings of white dominance in multiracial groups (Cohen, 1972, 1973; Cohen & Roper 1972). An explanation for this finding may involve smaller status differences between white and minority students than are usually encountered, due to the high level of the classes examined in the present study. The classes were in the highest track of general mathematics in the school. Therefore, students in these classes may have expected competent performance by all of their peers.

Finally, the higher incidence of receiving explanations for extroverted students than for introverted students is consistent with the literature finding positive correlations between participation in groups and measures of extroversion-introversion (Bass, McGehee, Hawkins, Young, & Gebel, 1953; Grosz & Wagner, 1971; Stern & Grosz, 1966; Webb, 1981). It is not clear, however, why the same relationship did not hold for giving explanations and achievement. More data are needed to explain these findings.

The Interaction Variables: Substantive and Methodological Issues

The interaction variables and procedures used in the present study help account for the strength of the relationships found here. The findings of this study document the importance of examining sequences of student behaviors rather than isolated interaction events. The combinations of the behavior eliciting a response (making an error, asking a question) and the response itself (no response, the correct answer only, an explanation) were potent predictors of learning; much stronger than the single behaviors used to predict learning in most studies. The sequential nature of these interaction variables also points out a limitation of the time-based rotating sampling systems which are often used to observe group interaction. In these systems, students are each observed for short intervals, usually too short for recording sequences of interchanges among students.

The tape-recording procedures captured not only the sequences interaction but also the rich detail of group discussions. The detailed records made it possible to code errors, to differentiate between different kinds of questions and, most importantly, to distinguish different kinds of responses to questions and errors. Even with sophisticated observation instruments, it is difficult to reliably distinguish between explanations and terminal feedback. Furthermore, because one student's question and another student's response were often separated in time or by other group interaction, verbatim records made it possible to determine whether a student's question was answered. Finally, the recording procedures made it possible to capture all of the group interaction, even when several group members spoke at once, and even when the group was surrrounded by nine other groups also actively engaged in group discussion.

Footnotes

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1. Several studies have examined the relationship between the amount of helping in the group and achievement (e.g., Hanelin, 1978; Slavin, 1978), but because they did not distinguish between giving help and receiving help their results are not discussed here.

2. The significance levels are reported for one-tailed tests except where specified otherwise.

References

Anderson, L. M., Evertson, C. M., & Brophy, J. E. An experimental study of effective teaching in first-grade reading groups. The Elementary School Journal, 1979, 79, 193-273.

Bargh, J. A., & Schul, Y. On the cognitive benefits of teaching. Journal of Educational Psychology, 1980, 72, 593-604.

Bass, B. M., McGehee, C. R., Hawkins, W. C., Young, P. C., & Gebel, A. S. Personality variables related to leaderless group discussion behavior. Journal of Abnormal and Social Psychology, 1953, 48, 120-129.

Battle, E. S., & Rotter, J. B. Children's feelings of personal control as related to social class and ethnic group. Journal of Personality, 1963, 31, 482-490.

Callahan, L. G., & Glennon, V. J. Elementary school mathematics: A guide to current research. Washington, D.C.: Association for Supervision and Curriculum Development, 1975.

Carmean, S. L., & Weir, M. W. Effects of verbalizations on discrimination learning and retention. Journal of Verbal Learning and Verbal Behavior, 1967, 6, 545-550.

Cohen, E. G. Interracial interaction disability. Human Relations, 1972, 25, 9-24.

Cohen, E. G., Modifying the effects of social structure. American Behavioral Scientist, 1973, 16, 861-879.

Cohen, E. G., Lockheed, M. E., & Lohman, M. R. The center for interracial cooperation: A field experiment. Sociology of Education, 1976, 49, 47-58.

Cohen, E. G., & Roper, S. S. Modification of interracial interaction disability: An application of status characteristic theory. American Sociology Review, 1972, 37, 643-657.

Crandall, V. C., Katkovsky, W., & Crandall, V. J. Children's beliefs in their own control of reinforcements in intellectual-academic achievement situations. Child Development, 1965, 36, 91-109.

Cronbach, L. J., Gleser, G. C., Nanda, H., & Rajaratnam, N. The dependability of behavioral measurements. New York: Holt, Rinehart and Winston, 1972.

Davis, J. H. Verbalization, experimenter presence, and problem solving. Journal of Personality and Social Psychology, 1968, 8, 299-302.

Delbecq, A. L., & Kaplan, S. J. The myth of the indigenous community leader within the war on poverty. Academy of Management Journal, 1968, 11, 11-25.

Deutsch, M. An experimental study of the effects of cooperation and competition upon group process. Human Relations, 1949, 2, 199-231.

Deutsch, M. The effects of cooperation and competition upon group process. In D. Cartwright & A. Zander (Eds.) Group Dynamics: Research and Theory (2nd Ed.). New York: Row, Peterson & Co., 1960.

DiVesta, F. J., & Rickares, J. P. Effects of labeling and articulation on the attainment of concrete, abstract, and number concepts. Journal of Experimental Psychology, 1971, 88, 41-49.

Dolciani, M. P., Wooton, W., Beckenbach, E. F., & Markert, W. Modern school mathematics, Course 2. New York: Houghton Mifflin Co., 1967.

Eysenck, H. J., & Eysenck, S.B.G. Eysenck Personality Inventory. San Diego, California: Educational and Industrial Testing Service, 1968.

Fennema, E. Sex differences in mathematics achievement: A review. Journal for Research in Mathematics Education, 1974, 5, 126-139.

Fennema, E., & Sherman, J. Sex-related differences in mathematics achievement, spatial visualization, and sociocultural factors. American Educational Research Journal, 1977, 14, 51-71.

Fennema, E., & Sherman, J. Sex-related differences in mathematics achievement and related factors: A further study. Journal for Research in Mathematics Education, 1978, 9, 189-203.

Gagne, R. M., & Smith, E. C., Jr. A study of the effects of verbalization on problem solving. Journal of Experimental Psychology, 1962, 63, 12-18.

Grosz, H. J., & Wagoner, R. MMPI and EPPS profiles of high and low verbal interactors in therapy groups. Psychological Reports, 1971, 28, 951-955.

Hanelin, S. J. Learning, behavior, and attitudes under individual and group contingencies. Unpublished doctoral dissertation, University of California, Los Angeles, 1978.

Hilton, T. L., & Berglund, G. W. Sex differences in mathematics achievement: A longitudinal study. Journal of Educational Research, 1974, 67, 231-237.

Hotelling, H. The selection of variates for use in prediction, with some comments on the general problem of nuisance parameters. Annals of Mathematical Statistics, 1940, 11, 271-283.

Katz, I., Roberts, S.P., &.Robinson, J. M. Effects of difficulty, race of administrator, and instructions on Negro digit-symbol performance. Journal of Personality and Social Psychology, 1965, 2, 53-59.

Lefcourt, H. M., & Ladwig, G. W. The effect of reference groups upon Negroes' task persistence in a biracial competitive game. Journal of Personality and Social Psychology, 1965, 1, 668-671.

Lockheed, M. B. The modification of female leadership behavior in the presence of males. Princeton, N.J.: Educational Testing Service, 1976.

Maccoby, E. E., & Jacklin, C. N. The psychology of sex differences. Stanford, Ca: Stanford University Press, 1974

Peterson, P. L., & Janicki, T. C., Individual characteristics and children's learning in large-group and small-group approaches. Journal of Educational Psychology, 1979, 71, 677-687.

Peterson, P. L., Janicki, T.C., & Swing, S. R. Individual characteristics and children's learning in large-group and small-group approaches: Study II. American Educational Research Journal, in press.

Sherman, J. Mathematics, spatial visualization, and related factors: Changes in girls and boys, grades 8 - 11. Journal of Educational Psychology, 1980, 72, 476-482.

Sgan, M. L., & Pickert, S. M. Cross-sex and same-sex assertive bids in a cooperative group task. Child Development, 1980, 51, 928-931.

Slavin, R. E. Student teams and comparison among equals: Effects on academic performance and student attitudes. Journal of Educational Psychology, 1978, 70, 532-538.

Stern, H., & Grosz, H. J. Personality correlates of patient interactions in group psychotherapy. Psychological Reports, 1966, 18, 411-414.

Webb, N. M. Group process: The key to learning in groups. New Directions for Methodology of Social and Behaviorial Science: Issues in Aggregation, 1980, 6, 77-87. (a)

Webb, N. M. Group process and learning in an interacting group. The Quarterly Newsletter of the Laboratory of Comparative Human Cognition, 1980, 2, 10-15. (b)

Webb, N. M. An analysis of group interaction and mathematical errors in heterogeneous ability groups. British Journal of Educational Psychology, 1980, 50, 1-11. (c)

Webb, N. M. A process-outcome analysis of learning in group and individual settings. Educational Psychologist, 1980, 15, 69-83. (d)

Webb, N. M. Group composition, group interaction, and achievement in cooperative small groups. Paper presented at the annual meeting of the American Educational Research Association, Los Angeles, 1981.

Weir, M. W., & Helgoe, R. S. Vocalization during discrimination: Effects of a mixture of two types of verbalization patterns. Journal of Verbal Learning and Verbal Behavior, 1968, 7, 842-844.